

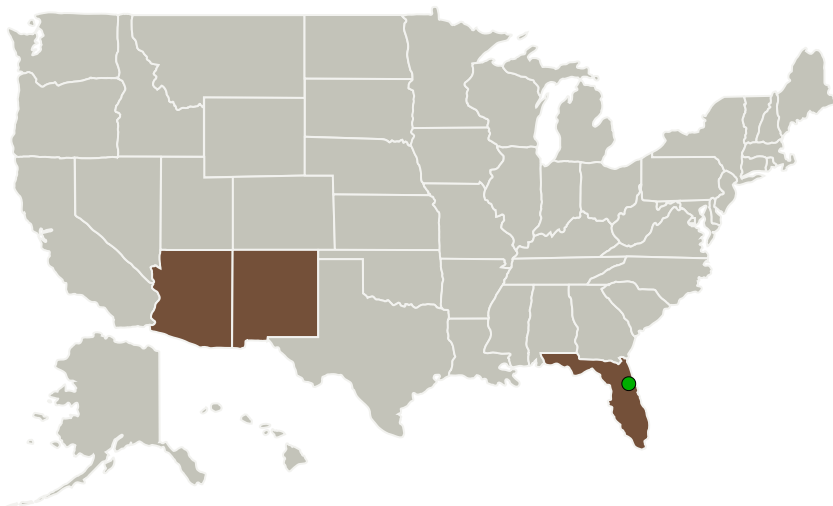
Multiscale GasKinetics/Particle (MGP) Simulation for Rocket Plume/Lunar Dust Interactions, Phase II

Completed Technology Project (2010 - 2012)

Project Introduction

An efficient and accurate software package named ZMGP (ZONA Multi-scale Gaskinetic/Particle simulation package) is proposed as a 3D tool to predict the lunar dust trajectory and crater formation process when a retro-rocket lands on the lunar surface. ZMGP has many special features including: 1, the hybrid flow module by coupling the gaskinetic Bhatnagar-Gross-Krook (BGK) model and the direct simulation Monte Carlo (DSMC) method (BGK/DSMC) to efficiently compute the rarefied flowfield; 2. by dividing the crater into different small slices, the Discrete Element Method (DEM) provides an accurate external Mass Erosion Rate (MER) database; 3. one Reduced Order Modeling (ROM) is built up from the vast DEM runs with the Neural Network (NNW) method, and then coupled with the BGK/DSMC module to predict the MER from the lunar surface; 4. integrating the lunar crater MER results provides the initial velocities for the dust particles off the lunar crater; 5. ZMGP utilizes an Overlay module or a two-species BGK module alternatively to produce the trajectories and shootout velocity of ejected particles. With finished concept verification for 2D case in Phase I, we plan to fully develop the software for 3D case and validate it with available experiment data in Phase II.

Primary U.S. Work Locations and Key Partners



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| Organizations Performing Work | Role | Type | Location |
|-----------------------------------------|-------------------------|---------------------------------------------|-------------------------------|
| ZONA Technology, Inc. | Lead Organization | Industry Small Disadvantaged Business (SDB) | Scottsdale, Arizona |
| ● Kennedy Space Center(KSC) | Supporting Organization | NASA Center | Kennedy Space Center, Florida |
| New Mexico State University-Main Campus | Supporting Organization | Academia | Las Cruces, New Mexico |

Primary U.S. Work Locations

| | |
|------------|---------|
| Arizona | Florida |
| New Mexico | |

Project Transitions

▶ **August 2010:** Project Start

✓ **August 2012:** Closed out

Closeout Documentation:

- Final Summary Chart(<https://techport.nasa.gov/file/139269>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

ZONA Technology, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

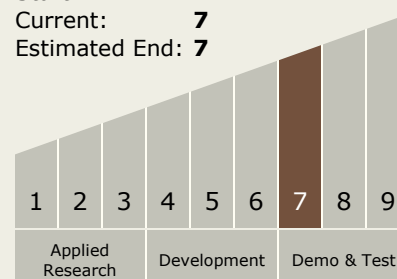
Carlos Torrez

Principal Investigator:

Shuchi Yang

Technology Maturity (TRL)

Start: 7
Current: 7
Estimated End: 7



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Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
 - └ TX09.4 Vehicle Systems
 - └ TX09.4.5 Modeling and Simulation for EDL

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System